Homogeneity testing of climate data and homogenization for RClimDex

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Homogeneity Testing / Homogenisation

Background:
The aim of climate data homogenisation is to adjust observations, if necessary, so that all variations in the data series are caused by real changes in the climate, and not due to changes in the way the data have been recorded.

Aim:
To test data series for homogeneity.

This procedure will involve testing daily/monthly temperature data series without the use of a homogeneous reference series, the most common scenario for stations in the North African/Arab region. Instructions for homogeneity testing with a reference series can be found in the *RHtest* User Manual.

Homogeneity Testing / Homogenisation

Software:

Daily/monthly temperature data is homogenised with "*RHtestV3*". This is an *R* application written by Xiaolan Wang and Yang Feng (Environment Canada). It includes functions to detect potential discontinuities in a candidate (or base) climate series. The software is available at http://cccma.seos.uvic.ca/ETCCDMI/software.shtml.

Metadata:

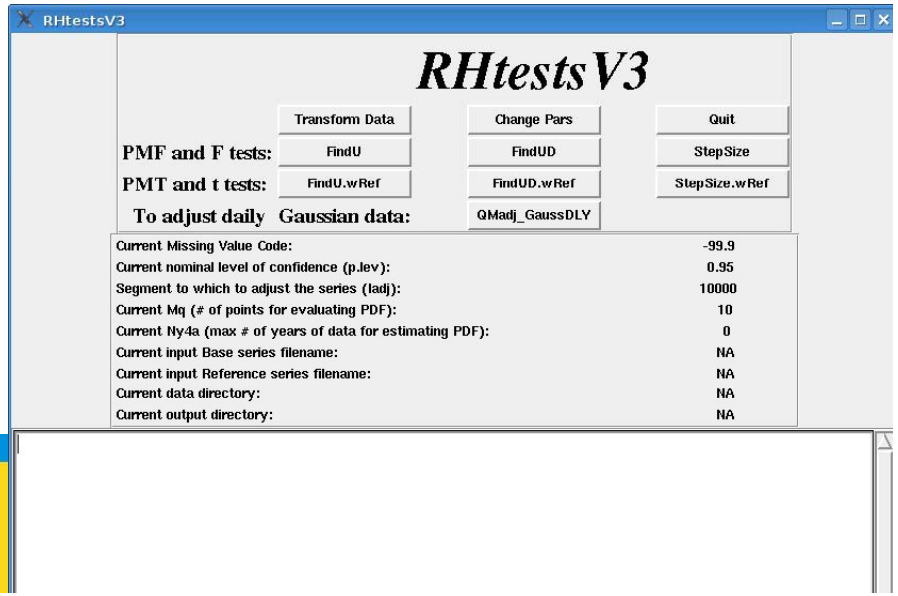
If available, completed station history sheets will assist in assessing whether any of the detected breakpoints could be due to changes in the way the data have been measured.

Step-by-step instructions to use RHtest

(0. Set up *R* on your computer using the *R* set-up file available at: http://www.r-project.org/ and create a new working folder. Copy *RHtestV3.r* and station data to be tested for homogeneity to your new working folder.)

1. Start *R* by clicking the icon on your desktop and change the working directory to your new folder (Click *File; Change dir..*). Then start *RHtest* by selecting *RHtestV3.r* (Click *File; Source R code…).*

2. To start the user-interface, enter *StartGUI()* at the *R* prompt.

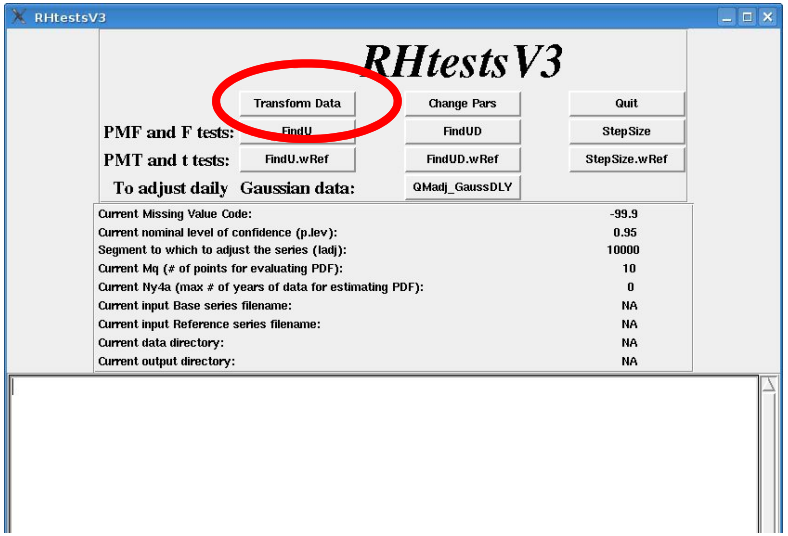


4. convert RClimdex data format to RHtest data format

Any data that is in the RClimdex 6-column (*years,months, days, Tmax, Tmin, Precip)* format will need to be converted to *RHtest* format before it can be tested for homogeneity. To do this:

a) From the RHTest GUI, click *Transform Data*
b) Select the station that you want to transform, click *Open.*
c) This will produce 9 files -
*_tmaxMLY.txt, *_tminMLY.txt, *_prcpMLY.txt,
*_tminDLY.txt, *_tmaxDLY.txt,
*_prcpDLY.txt, *_prcpMLY1mm.txt,
*_LogprcpMLY.txt, and *_LogprcpMLY1mm.txt

* = the input file name
DLY – daily data
MLY = monthly data
MLY1 = daily precipitation ≥ 1mm



d. The following files will be used in subsequent sections -
*_tminMLY.txt and *_tmaxMLY.txt / *_tminDLY.txt and *_tmaxDLY.txt

5. Change point detection

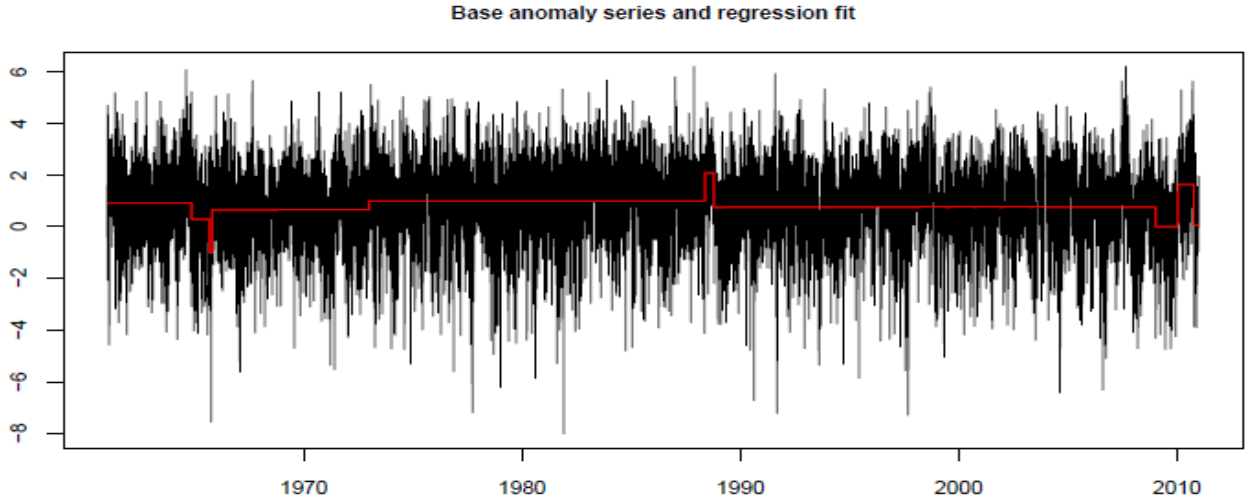
click the *FindU* button to start testing the data series without a reference series.

The function will then detect all changepoints that are significant at the 5% level in your data, even without metadata support (**Type-1 changepoints**).
A series of output files describing the test results will be produced in an *output* folder in your working folder:

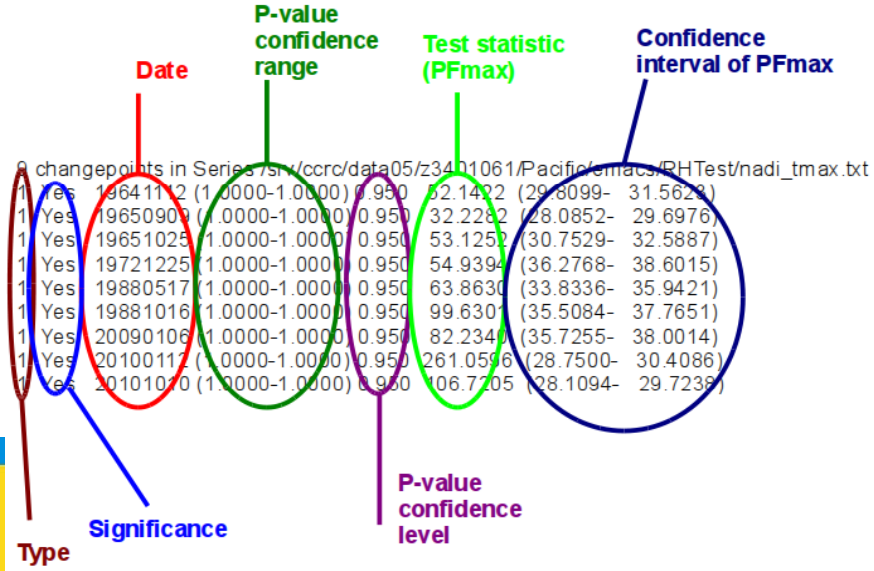
Name	Size	File Type	Modified	Permissions	Owner	Group
nadi_tmax_Ustat.txt	2.9 KB	Plain Text Docu...	06/03/12 10:48 am	-rw-------	z3401061	unsw
nadi_tmax_mCs.txt	744 B	Plain Text Docu...	06/03/12 10:48 am	-rw-------	z3401061	unsw
nadi_tmax_1Cs.txt	744 B	Plain Text Docu...	06/03/12 10:48 am	-rw-------	z3401061	unsw
nadi_tmax_U.pdf	1.9 MB	PDF Document	06/03/12 10:48 am	-rw-------	z3401061	unsw
nadi_tmax_U.dat	1.2 MB	Plain Text Docu...	06/03/12 10:48 am	-rw-------	z3401061	unsw

5. Change point detection

The *<filename> U.pdf* file shows the tested data series with identified breakpoints overlaid



The *<filename>_1Cs.txt* file lists all changepoints that are significant at the 5% level even without metadata support (**Type-1 changepoints**).



6. Edit change point file for known changes

add (using Notepad) any known changepoints to the *<filename>_mCs.txt* file by considering station history (metadata) information. (**"type-0 changepoints":** changepoints that can only be significant if supported by metadata).

In this example, metadata records for Nadi are relatively complete and it is known that the station underwent site moves in:
June 1965, May 1971, December 1985 and April 1998.

-> edited *<filename>_mCs.txt* file:

```
7 changepoints in Series
/srv/ccrc/data05/z3401061/Pacific/emacs/RHTest/nadi_tmax.txt
0 Yes   19650601 (1.0000-1.0000) 0.950   32.2282 (   28.0852-   29.6976)
0 Yes   19710501 (1.0000-1.0000) 0.950   54.9394 (   36.2768-   38.6015)
0 Yes   19851201 (1.0000-1.0000) 0.950   63.8630 (   33.8336-   35.9421)
0 Yes    19980401
1 Yes   20090106 (1.0000-1.0000) 0.950   82.2340 (   35.7255-   38.0014)
1 Yes   20100112 (1.0000-1.0000) 0.950  261.0596 (   28.7500-   30.4086)
1 Yes   20101010 (1.0000-1.0000) 0.950  106.7205 (   28.1094-   29.7238)
```

(7. test for “type-0” change points)

(can be skipped if station history is complete or no station history available)

click *FindUD* button
(this does not need to be done in this example as the dates of all known site moves have already been added to the *<filename>_mCs.txt* file.)

8. re-asses the significance and magnitude of all change points

Changing the number of changepoints will affect the significance of all changepoints. So click the *StepSize* button to re-assess the significance and magnitude of the new changepoints. Click *OK* to proceed.

9. Determine which change points are significant

examine results in the file *<filename>_fCs.txt*

```
7 changepoints in Series /srv/ccrc/data05/z3401061/Pacific/emacs/RHTest/nadi_tmax.txt
0 Yes   19650601 (    1.0000-    1.0000) 0.950   51.5468 (   32.3474-   34.3050)
0 YifD  19710501 (    1.0000-    1.0000) 0.950   18.2208 (   36.1032-   38.3996)
0 YifD  19851201 (    1.0000-    1.0000) 0.950   36.0256 (   38.4693-   40.9792)
0 No    19980401 (    0.8809-    0.9066) 0.950   -3.9025 (   36.9877-   39.3639)
1 Yes   20090106 (    1.0000-    1.0000) 0.950   94.3808 (   32.8130-   34.8125)
1 Yes   20100112 (    1.0000-    1.0000) 0.950  257.7519 (   29.1818-   30.8537)
1 Yes   20101010 (    1.0000-    1.0000) 0.950  105.4842 (   28.5294-   30.1567)
```

Remove any changepoints found to be not statistically significant from *<filename>_mCs.txt*

Deleting any changepoints will affect the significance of the remaining changepoints. So click the *StepSize* button again to reassess their significance and magnitude.

```
6 changepoints in Series /srv/ccrc/data05/z3401061/Pacific/emacs/RHTest/nadi_tmax.txt
0 Yes   19650601 (    1.0000-    1.0000) 0.950   45.1182 (   32.3767-   34.3359)
0 Yes   19710501 (    1.0000-    1.0000) 0.950   63.9958 (   36.1375-   38.4354)
0 YifD  19851201 (    1.0000-    1.0000) 0.950   22.0735 (   42.4176-   45.2812)
1 Yes   20090106 (    1.0000-    1.0000) 0.950   75.0505 (   37.3992-   39.8107)
1 Yes   20100112 (    1.0000-    1.0000) 0.950  260.0614 (   29.2067-   30.8804)
1 Yes   20101010 (    1.0000-    1.0000) 0.950  104.5662 (   28.5538-   30.1826)
```

10. Review significant change points

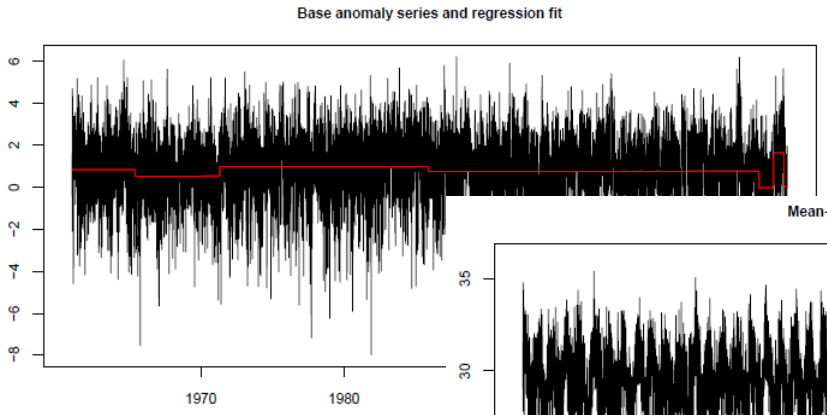
repeat ‘StepSize’ until all remaining change points are statistically significant…

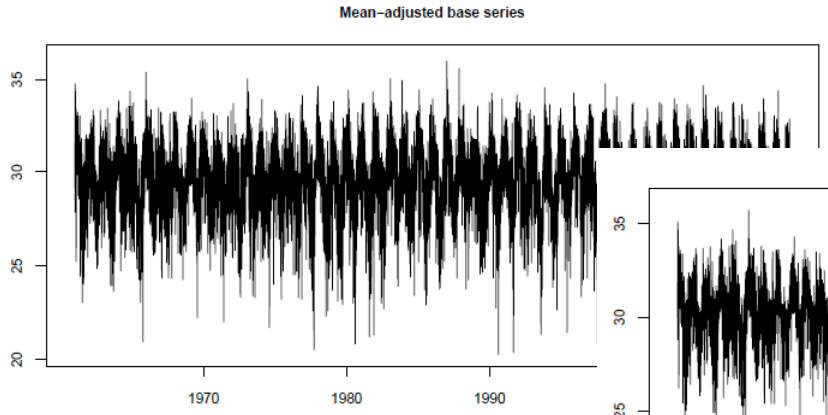
Once you are satisfied with the final changepoints, the following four final output files will be in the *output* directory:

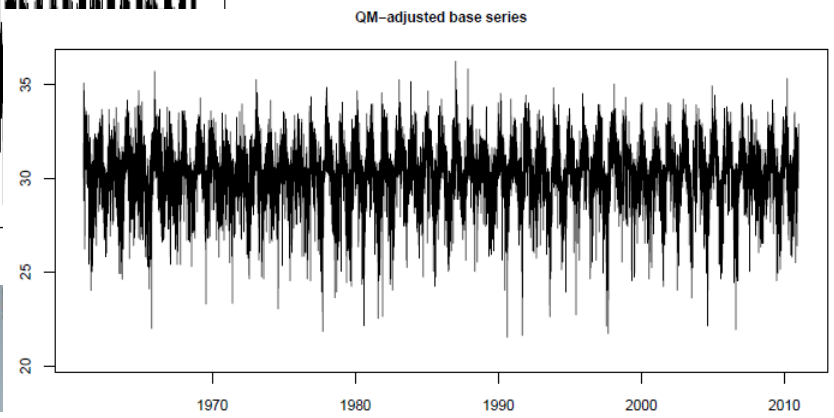
(i) *<filename>_fCs.txt* lists the changepoints identified and their significance;
(ii) *<filename>_Fstat.txt* stores the estimated shift-sizes and a copy of the content from the previous file;
(iii) *<filename>_F.dat* stores the original base series in its 3rd column, the mean adjusted series in its 5th column, and Quantile-Matching (QM) adjusted series in its 9th column, and
(iv) *<filename>_F.pdf*, shows plots of the original (base) series with breakpoints overlaid and adjusted series

10. Review significant change points

Country	Station Name	WMO No.	Variable tested	Detected CPs yyyymm	Final CPs yyyymm	Reasons for CPs	Base trend	Adjusted trend
Fiji	Nadi		Max Temp	**19641112** **19650909** **19651025** **19721225** **19880517** **19881016** **20090106** **20100112** **20101010**	**19650601** **19710501** **19851201** **20090106** **20100112** **20101010**	Site move Site move Site move ? ? ?	-0.00048°C / decade	0.00024°C/ decade





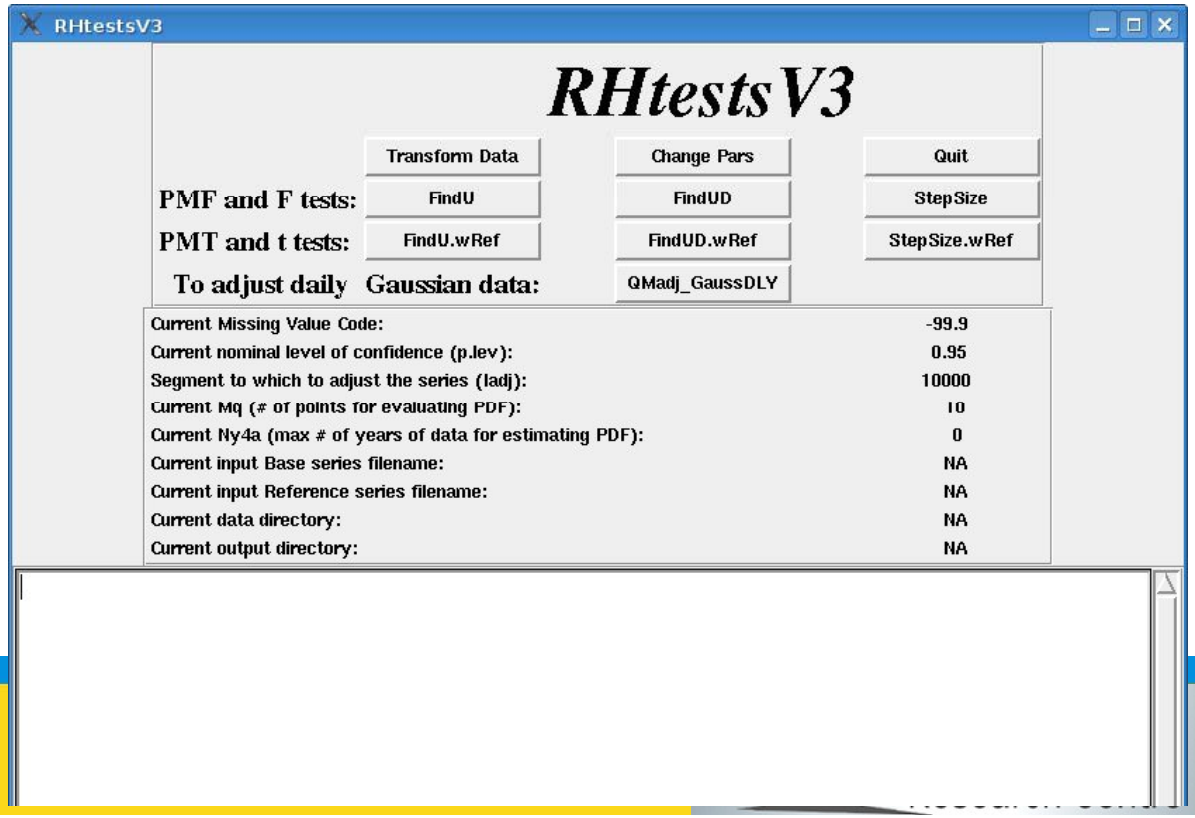


Discussion

- Do any of the calculated trend values differ substantially between raw and adjusted series for the stations you tested?
- *RHtestV3* can also be used for detecting discontinuities in base series that is compared to reference series. What could be used as a reference series in your country?
- What factors might prevent a homogeneity test from detecting an inhomogeneity?
- What factors might make a homogeneity test detect an inhomogeneity that does not really exist?

Quickguide

- source('RHtestsV3.r')
- StartGUI()
- TransformData
- FindU
- (FindUD)
- Stepsize (repeat until all changepoints significant)



Now hands on…

1. Run Quality Control in RClimDex

2. Test homogeneity of data, using RHTest

!! Keep a copy of your data in a safe place !!

[Recommendation: create a 'work' directory, copy your data files there, and only work on this copy]